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A REVIEW OF DATE INVESTIGATIONS AT THE U. S. DATE FIELD STATION, INDIO, CALIFORNIA

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ESTABLISHMENT

In 1904, the U. S. Department of Agriculture began an experimental date garden on leased land 2 miles east of Mecca in the Coachella Valley of California. This first station was established in cooperation with the California Agricultural Experiment Station but from the beginning was operated by the Federal Government. Three years later, because of the threatened flooding of the Mecca Station by the rising waters of the newly formed Salton Sea, headquarters for experimental work were moved to a new location 2 miles west of Indio where 10 acres for this purpose was donated to the Federal Government by Fred N. Johnson. A little later the U. S. Department of Agriculture acquired 21 additional acres of adjacent land. However, about 6 acres is taken up by the Whitewater storm channel and 5 acres more by buildings, lawns and roadways so that only about 20 acres is actually available for experimental plantings. This second station, now known as the U. S. Date Field Station, has been the center for date research since its establishment but some work was carried on at Mecca for about 25 years before it was discontinued. The U. S. Date Field Station has played an important part in the development of the date industry in the United States and through its research has greatly extended our scientific knowledge of the date palm and the conditions necessary for optimum fruit production (Reuther 1946).

In the present paper the accomplishments of the U. S. Date Field Station are summarized. Considerations of space enforce brevity but the importance of the major contributions and the nature of other work are indicated so that the program may be understood and evaluated. Detailed information about all the subjects mentioned can be found in the literature cited.

In the literature list it has seemed desirable to include all the publications on dates by members of the U. S. Department of Agriculture. Most of the research reported in the present summary has been done at the U. S. Date Field Station or by members of the staff. Studies on storage and handling have been conducted by specialists in that field who have had their headquarters part of the time at the U. S. Date Field Station and part of the time elsewhere. Those directly charged with the administration of date research have, from the beginning, sought and encouraged the cooperation of other divisions of the Department of Agriculture in solving particular problems requiring special facilities and skills not available at the U. S. Date Field Station. In the list of publications, an asterisk indicates workers who have not at any time been connected with the Indio station. The dates in parentheses refer to papers published in that year by the worker indicated as listed in the bibliography. Research done entirely by workers not connected with the U. S. Department of Agriculture is not listed even though in some instances the projects were taken up at the request or suggestion of the Department and date material was furnished by the U. S. Date Field Station.

EXPLORATION AND IMPORTATION

During the last half of the 19th century the fruiting of a few seedling date palms in various parts of the hot interior valleys of California and southern Arizona called attention to the possibilities for date culture in this region and led the U. S. Department of Agriculture to send explorers to the date growing countries of the Old World to study the conditions necessary for date culture and to import offshoots of the best varieties for trial in this country. Walter T. Swingle (1901, 1904, 1947) went to Algeria for this purpose in 1899 and again in 1900. The second year he made the first successful importation of date offshoots of superior varieties including the Deglet Noor, already well known in European markets. His studies of climatic and soil conditions in southern Algeria, followed by similar studies in the arid Southwest, led to the establishment of a date experiment station in the Coachella Valley in 1904 as previously mentioned and date investigations were conducted under his general supervision for three decades.

Swingle was followed by other explorers, whose studies of dates were either inspired or directed by him. In 1901-02, David Fairchild* (1903) made experimental importations of offshoots of some of the best date varieties from Iraq, Baluchistan and Egypt. In 1905, T. H. Kearney* (1905,1906,1948) obtained a collection of the best varieties from Tunisia. In 1913, 1920 and 1922, S. C. Mason (1915b, 1923, 1927) visited Egypt, secured offshoots of Hayany, Saidy and other leading varieties and cleared up confusion in regard to their nomenclature.

In 1927, Swingle (1929, 1945; Thackery 1952) obtained from Morocco, 11 offshoots of the Medjool date, formerly the leading export variety of that country. These offshoots were planted and the variety propagated until sufficient offshoots were available for distribution. Beginning in 1944 and continuing until the supply was exhaused in 1951, over 1600 offshoots of the Medjool were distributed among date growers under cooperative agreements for testing in the Coachella, Imperial, Yuma and Salt River Valleys. Limited quantities of fruit are now appearing on the market. The Medjool brings a premium because of its large size and attractive appearance and is increasing in favor as a choice dessert date.

In 1928-29, Roy W. Nixon studied date varieties in Iraq and made an importation of offshoots for testing in southwest Texas (1930a, 1930b). Amir Hajj, one of the varieties introduced at that time is a date of better-than-average quality and has shown considerable resistance to souring (1950d).

VARIETY STUDIES

Adaptation. In addition to the variety collections at the U. S. Experiment Stations, specimens of the more promising varieties available were, over a period of some 3 decades, furnished to date growers for testing in new localities in various parts of southern California and Arizona and to the Texas Agricultural Experiment Stations at Weslaco and Winter Haven. Much valuable information as to the behavior of the different varieties under varying conditions has been obtained from these tests and is incorporated in reports dealing with various phases of adaptation (Nixon 1933, 1937, 1942a, 1950c, 1950d).

Identification and Description. In studying the adaptation of varieties it was necessary also to determine their identity for there was much confusion in all the importations. In some instances the same variety was imported under several different names; in others several different varieties were imported under the same

name. It was apparent that inferior dates had been substituted for, or accidentally mixed with, better varieties, and the identity of many of the varieties, even some of the best, was in doubt. This was more or less inevitable because very little study of varieties had previously been made in the old World and little or no descriptive information was available for most of them. From studies of all the different dates imported the number and character of the different varieties were finally determined and it was possible by subsequent investigations in the countries of origin to learn the identity of the more important varieties that had been brought in under incorrect labels (Mason 1915a, 1915b, 1923, 1927; Nixon 1934c, 1945b, 1950d, 1951c, 1952a, 1954a, 1954b).

Although practically all date varieties are believed to have originated from seeds, the discovery of a few bud mutations has indicated the possibility of new types originating in this way (Mason 1930; Shamel* 1930; Nixon 1953c).

Breeding. The possibilities for eventual improvement of the date industry by means of a breeding program have long been recognized. There is no commercial date variety that does not have some defects such as, for example, the extreme sensitivity of the Deglet Noor fruit to damage from high humidity or the very short fruitstalks of the Medjool variety which increase breakage and difficulty in handling the bunches. Also, better males are needed as most of those in use are miscellaneous seedlings lacking many desirable characters. Little has been done in the past because of the time and space required for such a project and the pressure of more immediate problems that could be solved more quickly. A small start in breeding was made in 1940 but had to be discontinued two years later because the experimental farm on which the planting was located was abandoned by the Indian Service which operated it. However some of the palms were saved by transplanting to the Indio station and one has proved to be a male of some promise as its pollen stimulates large size and fairly early ripening of the pollinated fruit (Nixon 1955).

The present date breeding project is conducted cooperatively by the newly established U. S. Southwestern Irrigation Field Station at Brawley, California and the U. S. Date Field Station at Indio. In 1951 funds for date and citrus breeding were allotted to the Brawley station, land was made available there for planting seedlings and the superintendent of the U. S. Date Field Station was made a staff member of the Brawley station and placed in charge of the cooperative breeding project of the two stations. Seeds of the best commercial date varieties and some others with certain desirable characters were planted at Brawley in 1951, 1953 and 1954. By using males from the seedlings for back crosses on the female parent it is believed that male strains that will increase the possibility of transmitting the desired characters through pollen may be developed. The final objective, of course, is to combine in one variety desirable characters now found only in different varieties. This is obviously a long-term project for even after a new and better date is originated it will require many years to increase it by means of offshoots to the status of a commercial date. However, there should be advantages from the development of new and better males within a much shorter time, for one good male may supply pollen for 100 or more fruiting palms..

DATE INSECTS

Parlatoria Scale Eradication. Parlatoria scale (Parlatoria blanchardi[Targ.]) was introduced with the first importations of date offshoots and was soon recognized as a serious pest. In 1913 the U. S. Department of Agriculture began a campaign of inspection and treatment using a method of defoliation and torching of infested palms

previously worked out by the Arizona Agricultural Experiment Station. With the cooperation of the states of Arizona and California, this program, directed in later years by the Bureau of Entomology of the U. S. Department of Agriculture with headquarters at Indio, was finally successful in eradicating Parlatoria scale, generally regarded as the worst menace ever faced by the date industry in the United States (Shamblin 1924; Boyden 1929 to 1934, incl. - progress reports of date scale eradication, 1941).

Entomological investigations. Laboratory and field investigations of all insects found on the date palm in the United States have provided valuable information concerning their life history and methods of control (Borden* 1921; Stickney 1924, 1934a, 1934b; Stickney, Barnes* and Simmons* 1950; Barnes* and Lindgren* 1946, 1947). From taxonomic studies it was found that the date mite that attacks fruit in the United States is a different species from the one that occurs in the Old World (McGregor* 1939).

POLLINATION

Duration of Receptivity of Female Flowers. The length of time female flowers are receptive to pollen was determined by early experiments. It was shown that the longer pollination is delayed after the opening of the spathe the poorer the set and if more than a week elapses pronounced reduction in yield is likely to occur (Leding* 1928).

Direct Effect of Pollen on Fruit. Investigations conducted at the U. S. Date Field Station, supplemented by numerous tests in commercial date gardens, have proved that pollen not only influences the size and shape of the seed but also has a direct effect on the size and time of ripening of the fruit (Nixon 1926, 1927a, 1927b, 1928a, 1928b, 1928c, 1931a, 1934a, 1934b, 1936b, 1955, 1956; Crawford 1935). This discovery has attracted widespread attention among botanists and horticulturists because it was the first conclusive proof of a direct effect of pollen on fruit outside the embryo and endosperm of the seed, a phenomenon for which a new name, metaxenia, was coined (Swingle 1928).

The maximum differences obtained by the use of different pollens have varied from about 10 days when fruit ripens early in hot weather to as much as 2 months when fruit ripens late in cool weather. Practical use of this effect of pollen has been made by a few growers in localities where some Deglet Noor fruit sometimes does not ripen until February or March; by selecting a pollen known to induce early ripening and using it for pollinating flower clusters in the latter part of the season, it has been possible to complete the harvest by the end of December. By proper selection of pollen, dates can undoubtedly be ripened in many localities where they have never reached maturity before.

Storage of pollen. Dry pollen stored at ordinary room temperatures under desert conditions has been found to lose its viability before the next pollination season. The higher the temperature the more rapidly the pollen deteriorates (Gerard 1932). However, experiments have shown that pollen kept in a dry condition in cold storage may be held from one season and used satisfactorily the next (Crawford 1938a, 1938b; Aldrich and Crawford 1941). Many growers now store pollen from one year to the next for use early in the season when there is often not enough fresh pollen.

Pollen Germination. Poor sets of fruit are sometimes associated with cold weather during the early part of the pollination season. Experiments have shown that by enclosing the flower cluster in a paper bag, set may be materially improved when temperatures are low (Reuther and Crawford 1946). Bagging of flower clusters early in the season is now practiced by some growers as an insurance against poor sets.

FRUIT THINNING

Experimental studies with the more important commercial varieties of dates have shown the relation of the amount and method of fruit thinning to size of fruit, time of ripening and such quality factors as shrivel, checking and blacknose, (Nixon 1935, 1936a, 1940, 1942b, 1951b; Nixon and Crawford 1942). This information has provided a background for the evolution of methods of bunch thinning adapted to the peculiarities of the different varieties.

LEAF PRUNING

Studies of leaf pruning have been made along with fruit thinning for many years. After learning that the ratio of leaves to fruit cannot be lowered beyond a certain point without loss of quantity and quality of production, it was found that date palms under favorable growing conditions may acquire and retain more green leaves than are necessary for maximum fruit production and that, at least in the Deglet Noor variety, an excess of leaves below the fruit bunches may result in lower quality by increasing checking, blacknose and shrivel (Nixon 1938, 1943, 1947).

Investigations have been continued in an effort to get a better understanding of the relation of age and position of date leaves to fruit production. Recently through the cooperation of the Citrus Experiment Station, it has been possible with some of its expensive technical equipment to make laboratory tests of the efficiency in photosynthesis of detached portions of date leaflets of different ages (Nixon and Wedding* 1956). In these tests the food manufacturing ability of date leaves reached its maximum at about the time of full maturity (when the leaves were about a year old) and at the end of the second year it had begun to decline; at the end of the fourth year it was only about 65 percent as efficient as it was in its prime. It is to be expected that these differences in leaf efficiency are reflected in fruit production, but as evaluated in the field there is evidence from other experiments that, apart from age, the position of the leaf is also important and that the closer the leaf is to the base of the fruitstalk the more value it is to the fruit on that bunch. Data which will aid in the appraisal of leaf pruning practices have been obtained. They will be published in the near future.

IRRIGATION STUDIES

The relation between irrigation and the growth and fruiting of date palms has been studied over a number of years. The effects of varying degrees of soil moisture deficiency as related to different dates, amounts and frequencies of irrigation have been determined. It has been found that when any considerable proportion of soil in the principal root zone is near the wilting range of soil moisture for an appreciable length of time the rate of leaf growth is reduced. This growth rate is easily measured by attaching one end of a copper wire to a newly emerging but unexpanded leaf and checking its upward movement at intervals from the comparative

position of the lower end of the wire with reference to a fixed point, such as a spike driven into the palm trunk. The extent to which the reduced leaf growth produced by moisture deficiency will affect fruit production depends on the time, severity and duration of its occurrence. If leaf growth is reduced to 80 percent of normal or less over a period of several weeks during late spring and early summer when the fruit is growing rapidly, the growth rate and ultimate size of the fruit, both fresh and dry weight, will be reduced, grade lowered, and time of ripening hastened up to as much as 2 weeks. Susceptibility to checking and blacknose will also be reduced. As fruit nears maturity the effect on its size becomes progressively less. With palms in full production on a deep soil of high water-holding capacity, it has been found that if ample soil moisture is provided up to the middle of July, subsequent irrigations may be greatly reduced or omitted entirely for 2 or 3 months without reduction in yield or quality of fruit. Leaf growth may be reduced during this period but an acceleration of growth after normal irrigations are resumed compensates for this. Flowering may be delayed the following spring but slightly earlier ripening in the fall also compensates for this if leaf growth is again reduced by water shortage in early summer. However long intervals between irrigation are not recommended because of difficulties in salt removal and soil management.

These findings of course must be modified according to soil type. Applications of water in excess of field capacity have not been beneficial to Deglet Noor palms in a deep soil of high moisture-holding capacity but in a deep coarse sandy soil of low moisture holding capacity palms of the same variety were greatly benefited in production and quality of fruit as well as palm growth by supplementary irrigation in excess of that usually considered normal. (Swingle 1931; Moore 1938; Moore and Aldrich 1938; Aldrich and Moore 1940; Aldrich 1942; Reuther 1944; Reuther and Crawford 1945; Aldrich, Crawford and Moore 1946; Furr, Currlin, Hilgeman and Reuther 1951; Furr, Currlin and Armstrong 1952; Furr and Armstrong 1955; Furr 1956).

In another experiment in which irrigation water remained on the soil for several days after its application, fluctuations in soil atmosphere (oxygen and carbon dioxide) were measured but in spite of considerable variation there was no apparent injury to date palms in full production (Furr and Aldrich 1943).

FERTILIZATION

Studies of the fertilizer requirements of date palms have been concentrated chiefly on nitrogen, which in most western soils has been shown to be the only major element likely to be needed by tree crops. Soils available for studies at the U. S. Date Field Station are mostly good, permeable sandy loams with some silt and on such soils date palms have been slow to respond to applications of nitrogen. In one experiment Deglet Noor palms not quite in full bearing at the beginning, were given relatively large annual applications of nitrogen, 6 lbs. per palm the first 3 years and 8 lbs. per palm the last 4 years; growth and fruit production of the unfertilized palms were as good as those of the fertilized palms for the first 3 years but declined thereafter and during the last 4 years were about 20 percent less (Furr, Currlin, Hilgeman and Reuther, 1951). In a similar experiment with Khadrawy palms in full bearing applications of 8 lbs. of nitrogen per palm per year produced no significant increase in growth or fruit production during a period of 5 years, but in this case a cover crop of sweet clover grown on all plots each season may have supplied enough nitrogen for maximum fruit

production (Furr, Currlin and Armstrong 1952). Both experiments indicate that large applications of nitrogen may be wasteful if made without reference to soil type or condition of palms.

A study of the nitrogen content of soils in date gardens as compared with virgin, uncultivated soils nearby has shown that even after 30 years of cultivation there is very little difference except for a slight increase in the top foot. This indicates that there is relatively little accumulation of nitrogen from continued applications over a period of years and if applied in advance of need much of it may be lost. Although the percentage of nitrogen in desert soils is low (less than 0.1 percent) the total amount in the top 8 feet is estimated at 2000 to 15,000 lbs. per acre so that with a well-distributed root system in a good soil the palm may not suffer from lack of nitrogen for many years. It has been estimated that an acre of dates in full bearing removes from the soil about 69 lbs. of nitrogen per year (Furr and Barber 1950).

Chemical analyses have provided information as to the mineral constituents of date leaves and the changes that occur with age (Mason 1929; Reuther 1948). In experiments with nitrogen fertilization it has been found that significant differences in fruit production are accompanied by differences in the nitrogen content of the leaves and indicate that leaf analysis may prove useful in a study of the nitrogen needs of the date palm, but further data are needed to establish standards of reference (Furr and Cook 1952).

A study of the fertilizer value of date leaf and fruitstalk prunings which are chopped and returned to the soil by many growers, has shown that they add more organic matter than the average cover crop of Melilotus indica but are low in nitrogen (0.5 percent). To prevent the loss of nitrogen during the decomposition of the organic matter it was estimated that 58 lbs. of nitrogen per acre should be added to supplement the prunings (4800 lbs. of dry matter) of an average date garden (Embleton and Cook 1947).

Observations and study have shown that the date palm will tolerate more salt than most other tree crops, but growth may be seriously reduced without the development of prominent symptoms and there is no question but that it is better if the salinity of the soil is reduced (Eaton* 1937; Hayward* 1949).

OFFSHOOT HANDLING

Although it was early demonstrated that date offshoots detached from the palm can be rooted (Drummond 1919) it was shown by subsequent experience that the percentage of survival is higher and the cost of handling less if they are left on the palm until well rooted. In later experiments better growth and survival were obtained when the offshoots weighed more than 30 lbs. after being cut and trimmed for transplanting. The removal of most of the offshoots from a palm increased the size and later growth of those left for another year or two before cutting and transplanting; also the removal of offshoots increased the subsequent growth and flowering of the parent palm. The most desirable frequency of irrigation of the transplanted offshoots was found to depend on soil type: in a pervious fine sand or sandy loam irrigation every 2 or 3 days was most satisfactory for the first 40 days but in somewhat impervious soils, early intervals of 7 to 14 days, according to the length of time water stood on the surface, proved better (Aldrich, Leach and Dollins 1945; Hilgeman and Furr 1948).

COVER CROPS

Preliminary tests have been made with a number of possible cover crops for date gardens but they have not been followed up because of lack of space and personnel and the pressure of other more important projects. Of the winter cover crops tried the Hubam variety of sweetclover has given the best results. Of the summer cover crops, sesbania and Sudan grass have produced most tonnage but the Tepary bean has shown some promise (Thackery and Leach 1936).

DISEASES

Work on diseases of the date palm has not been attempted at the U. S. Date Field Station because pathological investigations have been conducted by the University of California Citrus Experiment Station from Riverside. However, the cause of one physiological disorder, checking and blacknose, was discovered and the conditions under which it occurs were determined. It was found that checking occurs only during periods of high humidity at the time when the date fruit has almost reached full size, just before turning from green to the red or yellow of the khalal stage which preceds final ripening (Nixon 1932). Later the physiological processes involved were studied and it was found that checking results when the loss of water by transpiration from the fruit is not sufficient to offset the influx of water into the fruit. When this occurs the cells at or near the surface of the fruit become enlarged and finally rupture as a result of high pressure. High atmospheric humidity checks transpiration from the fruit and increases the movement into the fruit through conductive tissues by also checking transpiration from the leaves. Excess soil moisture at this time supplies additional water to the fruit and increases the susceptibility to checking (Aldrich, Furr, Crawford and Moore 1946). An understanding of the conditions under which checking and blacknose occur makes possible the adaptation of cultural practices to reduce it.

MATURATION, STORAGE AND HANDLING

For various reasons it may be desirable or unavoidable to pick some dates at varying stages immediately before they are fully ripe and cured. One of the first problems investigated by the U. S. Department of Agriculture was how best to handle such dates to bring them to full maturity with optimum quality and to preserve it in storage. It was found that the best flavor and color of the Deglet Noor, the principal commercial variety, are obtained when the fruit is ripened and cured at a temperature of 95° or less and that the keeping quality is prolonged if the fruit is placed in cold storage when still slightly immature as indicated by the retention of a small portion of firm flesh ("rag") at the base. At 32° F. with moisture content not over 25 percent full-ripened fruit will remain in good condition for 5 to 6 months but slightly immature fruit, as described, may be stored satisfactorily for 9 to 10 months. (Swingle 1912, 1924b; Barger 1927; Sievers* and Barger 1930).

Early work and all subsequent investigations have emphasized that the most important single factor affecting keeping quality is the moisture content of the date. Dates with a moisture content higher than a certain critical point, about 25 percent for the Deglet Noor variety, are increasingly susceptible to deterioration as the moisture content increases, the temperature rises, or the storage is prolonged. Great variability of moisture content, often as much as 10 percent, among individual dates in a single container, has been shown to be a common source of spoilage by the time the packaged dates reach the consumer. Some of the dates may become too dry

in the course of time but more dangerous is the fact that one date of high moisture content may spoil very quickly and render the entire package unacceptable. Even before the dates become unacceptable they deteriorate more rapidly above the critical moisture content by darkening of color and loss of flavor (Barger 1934; Rygg, Furr, Nixon and Armstrong 1953; Rygg 1954b).

The correct humidity necessary in storage to maintain a given moisture content in the fruit has been worked out (Rygg 1948b, 1948c). A practical method was devised for the rapid determination of the moisture content of dates with a portable hand refractometer (Rygg 1938, 1945).

Information has been obtained as to the effect on the fruit of different methods and conditions of hydration and a technic was worked out for improving the appearance of such dates by adding a glaze or attractive luster to the skin (Barger 1936; Rygg 1944). It was discovered that sugar spotting of dates in storage is most likely to occur when the moisture content is between 22 percent and 33 percent and it is retarded by lowering the temperature in storage; it has been entirely prevented over a period of a year by a temperature of -10° F. (Barger 1933; Rygg 1942).

A method has been worked out for utilizing unpollinated dates of which there is occasionally some quantity. When left on the palm 2 to 4 months later than pollinated dates until the sugar was in excess of 65 percent of the dry weight or the moisture below 50 percent of the wet weight, unpollinated khalal dates have been ripened by holding them 2 to 4 days at 125 to 135° F. in high humidity; the resulting product is often somewhat fibrous and should not be used as whole fruit but is suitable for use in date products.

Subsequent ripening of unpollinated khalal dates was hastened by storage at 0° F. for 3 months (Rygg 1946b).

It is sometimes necessary to cut date bunches before all the fruit has ripened; it has been found that a larger percentage of such fruit will ripen and there will be less spoilage if it is left on the bunch. Freezing khalal dates at -10° F. after removal from the bunch hastened subsequent softening but the resulting quality was poor (Rygg 1950).

Over a period of 4 years during which there was no serious rain damage and only small differences in returns between grades, there was no gain by picking Deglet Noor fruit of relatively low quality more than twice (Furr and Armstrong 1954).

From a comparison of climatic data with packing house records it was discovered that a high percentage of dry Deglet Noor fruit has been produced when unseasonably high temperatures occurred during the period from the middle of April to the end of May (Rygg 1953, 1954a).

Much of the darkening of dates in storage has been thought to result from the oxidation of the tannin cells just under the skin; this is greatly reduced by a promising new method of canning dates with an inert atmosphere of nitrogen or carbon dioxide (Nielsen*, McColloch* and Beavens* 1950).

Some attention has been given to the problem involved in handling small lots of fruit at home or with improvised facilities and procedures have been suggested for such conditions (Barger 1940, Nixon 1951a).

TECHNICAL STUDIES

Some of the technical studies conducted at the U. S. Date Field Station do not have immediate practical application but are made for the purpose of learning as much as possible about the structure and growth processes of the date palm. Information acquired in this way provides a background for understanding the behavior of the date palm under varying conditions and often aids in the solution of cultural problems. It has been found that there is a critical temperature of about 50° F. below which growth of the date palm stops; some growth may occur when minimum temperatures are below this point provided maximum daily temperatures are above it (Mason 1925a). The fibrous structure of the date palm protects and insulates very effectively the bud and inner conducting tissue from extremes of heat and cold so that the temperature of the growth center and the ascending sap current is only slightly above that of the soil in the principal root zone (Mason 1925b). Leaf growth is inhibited by direct sunlight (Mason 1925c).

The roots of many monocotyledons will die back when cut but it has been found that the cut end of a date palm root may regenerate and continue growth (Peebles 1936).

It has been determined that plant food in the form of starch is stored in the trunk of the date palm; this reserve decreases during the summer and builds up during the remainder of the year (Aldrich and Young 1941).

The nature of the structural, physiological and chemical changes that take place during the development and ripening of the fruit are now better understood as a result of research in this field (Crawford 1933; Aldrich and Crawford 1939; Long 1943; Rygg 1946a).

A relatively low acid content (high pH value) has been found associated with high grade dates (Rygg 1948a). Sulfur dusting for mite control had no effect on the sulfur content of fruit; it was found that the fruit was more easily damaged by high temperatures in early summer than later (Rygg 1952a, 1952b).

Attempts to produce seedless fruit with chemical stimulants that have been used with some vegetable crops have not been successful with dates but the life of the perianth ("calyx") was considerably prolonged, indicating possibilities for further research in this field (Nixon and Gardner 1939).

The rapid increase in dry weight and sugar content which characterizes the khalal stage has been found to occur normally only at night (Curtis 1947).

The effect of different environmental conditions and treatments on maturity and quality of fruit at various stages has been studied. It has been found that fruit most exposed to sunlight ripens a little ahead of the rest of the bunch, even under covers; paper covers cause a slight retardation in ripening; there is more sunburn under brown paper covers than under white paper covers; white cold water paint is effective in reducing sunburn of fruitstalks which in varieties like Khadrawy is associated with severe fruit shrivel (Nixon 1946b; Nixon and Reuther 1947). Wax emulsion sprays applied during the khalal stage reduced shrivel but produced an abnormally dark color and an undesirable flavor in the ripe fruit accompanied by lower dry weight and somewhat later ripening (Reuther and Crawford 1944).

In a study of 51 varieties of dates, differences in the total sugar content of the fruit were, for the most part, too small and variable to suggest significance but with a few exceptions, the soft varieties contained little or no sucrose (cane sugar), the dry varieties relatively large amounts and the semi-dry varieties intermediate amounts (Cook and Furr 1952, 1953).

DISSEMINATION OF INFORMATION

An important part of any research program is to make available to the industry concerned the information acquired. Members of the staff of the U. S. Date Field Station frequently confer with date growers concerning specific problems and an appreciable amount of time is spent in answering correspondence relative to date culture. An effort is made to publish as soon as possible the results of research and study. Reports on specific research projects have already been listed. Information concerning cultural practices with suggestions based on experience and research have been made available to growers (Nixon and Moore 1939; Nixon 1945a, 1951a). In addition, many papers summarizing experience, observations and historical facts have been published; often these were written because of special requests for authoritative information. Among the various subjects that have been covered are the status and condition of the date industry from time to time (Swingle 1913, 1927; Mason 1915c; Nixon 1944, 1953b); certain phases of the Government program relating to dates (Swingle 1907, 1924a; Thackery 1931; Ryerson 1936); rainfall data (Mason 1926; Moore 1935); general information about the date palm (Nixon 1931b, 1946c, 1951d); men who imported offshoots (Nixon 1946a, 1947a, 1952b); date culture in other countries - Iraq and western Iran (Fairchild 1903; Nixon 1930a); Saudi Arabia (Nixon 1954a, 1954b); Egypt and Sudan (Mason 1915, 1923, 1925d, 1927); French North Africa - Tunisia, Algeria and Morocco (Swingle 1904, 1929, 1945; Kearney 1905; 1906, 1948; Nixon 1950a, 1950b, 1952a); Spain (Nixon 1950b); Baja, California (Nixon 1953a).

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE ON DATES*

Aldrich, W.W. 1942. Some effects of soil moisture deficiency upon Deglet Noor fruit. Date Growers' Inst. Rpt. 19: 7-10.

_____ and C. L Crawford. 1939. Dry weight increase curves for date fruit. Amer. Soc. Hort. Sci. Proc. 37: 187-190.

_____ and D. C. Moore. 1940. Relation of water supply by the date palm to water injury of the fruit. Date Growers' Inst. Rept. 17: 3-5.

_____ and C. L. Crawford. 1941. Second report upon cold storage of date pollen. Date Growers' Inst. Rept. 18: 5.

_____ and T. R. Young, Jr., 1941. Carbohydrate changes in the date palm during the summer. Amer. Soc. Hort. Sci. Proc. 39: 110-118.

_____, G. H. Leach and W. A. Dollins. 1945. Some factors influencing the growth of date offshoots in the nursery row. Amer. Soc. Hort. Sci. Proc. 46: 215-221.

* An asterisk follows the name of a worker who was not at any time connected with the Indio station.

_____, C. L. Crawford and D. C. Moore. 1946. Leaf elongation and fruit growth of the Deglet Noor date in relation to soil-moisture deficiency. Jour. Agr. Res. 72(5): 189-200.

_____, J. R. Furr, C. L. Crawford and D. C. Moore. 1946. Checking of fruits of the Deglet Noor date in relation to water deficit in the palm. Jour. Agr. Res. 72(6): 211-231.

Barger, W. R. 1927. Experiments in storage of Deglet Noor dates. Date Growers' Inst. Rpt. 4: 9-10.

_____ 1933. Experiments with California dates in storage. Date Growers' Inst. Rpt. 10: 3-5.

_____ 1934. The effect of humidity and containers on dates. Date Growers' Inst. Rpt. 11: 14-18.

_____ 1936. Experiments in hydrating dry Deglet Noor dates. Date Growers' Inst. Rpt. 13: 14-16.

_____ 1940. Handling and storing small lots of dates at home. U. S. Dept. of Agr. Circular 553.

Barnes, D.F.* and D. L. Lindgren* (Univ. Calif). 1946. The beetle infestation in dates. Date Growers' Inst. Rpt. 23: 34-35.

_____* (Univ. Calif.) 1947. Progress of work on beetle infestation in dates. Date Growers' Inst. Rpt. 24: 3-4.

Borden, A.D.* 1921. A biological study of the red date-palm scale, Phoenicococcus Marlatti. Jour. Agr. Res. 21(9): 659-667.

Boyden, B.L.* 1929-1934. Progress of date scale eradication campaign. Annual reports in Date Growers' Inst. Rpts. 6-11 incl.

_____* 1941. Eradication of the Parlatoria date scale in the United States. U. S. Dept. Agr. Misc. Pub. 433, 62 pp., illus.

Cook, J.A. and J. R. Furr. 1952. Sugars in the fruit of soft, semi-dry and dry commercial date varieties. Date Growers' Inst. Rept. 29: 3-4.

_____. 1953. Kinds and relative amounts of sugar and their relation to texture in some American-grown date varieties. Amer. Soc. Hort. Sci. Proc. 61: 286-292.

Crawford, C. L. 1933. Growth rate of Deglet Noor dates. Date Growers' Inst. Rept. 10: 8.

_____ 1935. Growth rate of Deglet Noor dates in Metaxenia. Amer. Soc. Hort. Sci. Proc. 33: 51-54.

_____ 1938a. Cold storage of date pollen. Date Growers' Inst. Rept. 15:20.

_____ 1938b. Effectiveness of date pollen following cold storage. Amer. Soc. Hort. Sci. Proc. 91-95.

Curtis, O.F. 1947. Diurnal translocation of carbohydrates into date fruits. Amer. Jour. Botany 34 (7): 388-391.

Drummond, Bruce. 1919. Propagation and culture of the date palm. U. S. Dept. Agr. Farmers' Bul. 1016, 23 pp., illus.

Eaton, F.M.*. 1937. Significance of salt in Coachella Valley agriculture. Date Growers' Inst. Rpt. 14: 11-13.

Embleton, T. W. and J. A. Cook. 1947. The fertilizer value of date leaf and fruit stalk prunings. Date Growers' Inst. Rpt. 24: 18-19.

Fairchild, David G.* 1903. Persian Gulf dates and their introduction into America. U. S. Dept. Agr. Bul. 54, 32 pp.,illus.

Furr, J.R. and W. W. Aldrich. 1943. Oxygen and carbon-dioxide changes in the soil atmosphere of an irrigated date garden on calcareous very fine sandy loam soil. Amer. Soc. Hort. Sci. Proc. 42: 46-52.

_____ and H. D. Barber. 1950. The nitrogen content of some date garden soils in relation to soil management practices. Date Growers' Inst. Rpt. 27: 26-30.

_____, E. C. Currlin, R. H. Hilgeman and W. Reuther. 1951. An irrigation and fertilization experiment with Deglet Noor dates. Date Growers' Inst. Rpt. 28: 17-20.

_____, E. C. Currlin and W. W. Armstrong. 1952. Effects of water shortage during ripening and of nitrogen fertilization on yield and quality of Khadrawy dates. Date Growers' Inst. Rpt. 29: 10-12.

_____ and J. A. Cook. 1952. Nitrogen content of Pinnae, fruit and seed of Deglet Noor and Khadrawy date palms as related to nitrogen fertilization. Date Growers' Inst. Rpt. 29: 13-14.

_____ and W. W. Armstrong. 1954. An investigation of the relation of frequency of picking Deglet Noor dates to grades, picking costs, and returns. Date Growers' Inst. Rpt. 31: 10-12.

_____. 1955. Growth and yield of Khadrawy date palms irrigated at different intervals for two years. Date Growers' Inst. Rpt. 32: 3-7.

Furr, J.R. 1956. Responses of citrus and dates to variations in soil-water conditions at different seasons. Internatl. Hort. Congress (1955) Rpt. 14 (in press)

Gerard, B. 1932. The effect of heat on the germination of date pollen. Date Growers' Inst. Rpt. 9: 15.

Hayward, H.E.* 1949. Salt tolerance of irrigated crops. Date Growers' Inst. Rpt. 26: 15-17.

Hilgeman, R.H. and J. R. Furr. 1948. How variations in soil moisture affected growth of Deglet Noor date palm offshoots. Date Growers' Inst. Rept. 25: 24-26.

Kearney, T.H.* 1905. Agriculture without irrigation in the Sahara Desert. U. S. Bur. Plant Industry Bul. 86, 30 pp., illus.

_____* 1906. Date varieties and date culture in Tunis. U. S. Bur. Plant Industry Bul. 92, 112 pp., illus.

_____* 1948. A winter among the date palms of Tunisia. Date Growers' Inst. Rept. 25: 18.

Leding, A.R.* 1928. Determination of length of time during which the flowers of the date palms remain receptive to fertilization. Jour. Agr. Res. 36 (2): 129-234.

Long, E.M.*. 1943. Developmental anatomy of the fruit of the Deglet Noor date. Bot. Gaz. 104)3): 426-436.

Mason, S.C. 1915a. Botanical characters of the leaves of the date palm used in distinguishing cultivated varieties. U.S. Dept. Agr. Bul. 223, 28 pp., illus.

_____ 1915b. Dates of Egypt and The Sudan. U.S. Dept. Agr. Bul. 271, 40 pp., illus.

_____ 1915c. The date in California. California's Magazine 1 (1) 470-476.

_____ 1923. The Saidy date of Egypt: a variety of the first rank adapted to commercial culture in the United States. U. S. Dept. Agr. Bul. 1125, 36 pp., illus.

_____ 1925a. The minimum temperature for growth of the date palm and the absence of a resting period. Jour. Agr. Res. 31 (5): 401-414.

_____ 1925b. Partial thermostasy of the growth center of the date palm. Jour. Agr. Res. 31(5): 415-453.

_____ 1925c. The inhibitive effect of direct sunlight on the growth of the date palm. Jour. Agr. Res. 31(5): 455-468.

_____ 1925d. Date culture in Sudan. Dept. Agr. & Forests. Khartoum 79 pp.

_____ 1926. Rainfall data. Date Growers' Inst. Rpt. 3: 14-15.

_____ 1927. Date culture in Egypt and the Sudan. U. S. Dept. Agr. Dept. Bul. 1457, 72 pp., illus.

_____ 1929. Relative moisture and ash content of green and partially dry palm leaves. Date Growers' Inst. Rpt. 6: 3-4.

_____ 1930. A sectorial mutation of a Deglet Noor date palm. Jour. Heredity 21 (4): 157-163.

McGregor, E.A.* 1939. The specific identity of the American date mite: description of two new species of Paratetranychus. Ent. Soc. of Wash. Proc. 41 (9): 247-256.

Moore, D. C. 1935. Rainfall as related to dates grown in the southwest. Date Growers' Inst. Rpt. 12: 11-12.

_____. 1938. The size of date fruit as affected by soil moisture. Date Growers' Inst. Rpt. 15: 3-4.

_____ and W. W. Aldrich. 1938. Leaf and fruit growth of the date in relation to moisture in a saline soil. Amer. Soc. Hort. Sci. Proc. 36: 216-222.

Nielsen, B.Ø.*, R. J. McCulloch* and E. A. Beavens*. 1950. Processing and packaging of dates. I. A new method of canning and pasteurizing Deglet Noor dates. Food Technology 4(6): 232-237.

Nixon, R. W. 1926. Experiments with selected pollens. Date Growers' Inst. Rpt. 3: 11-14.

_____ 1927a. Further evidence of the direct effect of pollen on the fruit of the date palm. Date Growers' Inst. Rpt. 4: 7-9.

_____ 1927b. Date pollination experiments in Salt River Valley. Associated Ariz. Producer 6: 12.

_____ 1928a. The direct effect of pollen on the fruit of the date palm. Jour. Agr. Res. 36: 97-128.

_____ 1928b. Pollination experiments in 1927. Date Growers' Inst. Rpt. 5: 5-7.

_____ 1928c. Immediate influence of pollen in determining the size and time of ripening of the fruit of the date palm. Jour. Hered. 19: 240-254.

_____ 1930a. Recent observations on date culture in Iraq. Date Growers' Inst. Rpt. 7: 4-5.

_____ 1930b. Phoenix Dactylifera L. (List of offshoots obtained from Iraq.) Plant material introduced by the Office of Foreign Plant Introductions, Bureau of Plant Industry, April 1 to June 30, 1929 (Nos. 80019-80810). U.S.D.A. Inventory No. 99, pp. 40-42.

_____ 1931a. The commercial utilization of differences in time of ripening of dates due to pollen. Date Growers' Inst. Rpt. 8: 5-6.

_____ 1931b. Palmaceae. Chap. 9 (pp. 63-72) in The Botany of Crop Plants, 3rd ed. rev., by W. W. Robbins, Phila.

_____ 1932. Observations on the occurrence of blacknose. Date Growers' Inst. Rpt. 9: 3-4.

_____ 1933. Notes on rain damage to varieties at the U. S. Experiment Date Garden. Date Growers' Inst. Rpt. 10: 13-14.

_____ 1934a. Recent pollination experiments. Date Growers' Inst. Rpt. 11:9-11.

_____ 1934b. Metaxenia in dates. Amer. Soc. Hort. Sci. Proc. 32:221-226.

_____ 1934c. The Dairee date, a promising Mesopotamian variety for testing in the southwest. U. S. Dept. Agr. Circ. 300, 12 pp., illus.

_____ 1935. Bunch thinning experiments with Deglet Noor dates. Date Growers' Inst. Rpt. 12: 17-19.

_____ 1936a. Further experiments in fruit thinning of dates. Date Growers' Inst. Rpt. 13: 6-8.

_____ 1936b. Metaxenia and interspecific pollinations in Phoenix. Amer. Soc. Hort. Sci. Proc. 33: 21-26.

_____ 1937. The freeze of January 1937 - discussion. Date Growers' Inst. Rept. 14: 19-23.

_____ 1938. Leaf pruning and fruit thinning following the freeze of January 1937. Date Growers' Inst. Rpt. 15: 25-29.

_____ 1940. Fruit thinning of dates in relation to size and quality. Date Growers' Inst. Rpt. 17: 27-31.

_____ 1942a. Rain and high humidity tolerance of commercial date varieties. Date Growers' Inst. Rpt. 19: 12-13.

_____ 1942b. Fruit shrivel of the Halawy date in relation to amount and method of bunch thinning. Amer. Soc. Hort. Sci. Proc. 41: 85-92.

_____ 1943. Flower and fruit production of the date palm in relation to the retention of older leaves. Date Growers' Inst. Rpt. 20:7-9.

_____ 1944. Dates in the United States. Amer. Fruit Grower 64: 9, 24, 26, 27.

_____ 1945a. Date culture in the United States. U. S. Dept. Agr. Circ. 728, 44 pp., illus.

Ryerson, K. A. 1936. The work of the United States Department of Agriculture for the date industry. Date Growers' Inst. Rpt. 13:3-4.

Rygg, G. L. 1938. A preliminary report on a simple and rapid method for determining the moisture content of dates. Date Growers' Inst. Rpt. 15:4-5.

_____. 1942. Factors affecting sugar spotting in dates. Date Growers' Inst. Rpt. 19:10-12.

_____. 1944. Glazing and hydrating dates. Date Growers' Inst. Rpt. 21:7.

_____. 1945. Determination of moisture in dates by means of a refractometer. Date Growers' Inst. Rpt. 22:3-4.

_____. 1946a. Compositional changes in the date fruit during growth and ripening. U. S. Dept. Agr. Tech. Bul. 910, 51 pp., illus.

_____. 1946b. Utilization of unpollinated Deglet Noor dates. Date Growers' Inst. Rpt. 23: 36-38.

_____. 1948a. Acidity in relation to quality in the date fruit. Date Growers' Inst. Rpt. 25: 32-33.

_____. 1948b. Storage humidity for dates. Date Growers' Inst. Rpt. 25:34-35.

_____. 1948c. Relative humidity for storing dates at different temperatures. Am. Soc. for Hort. Sci. Proc. 52: 173-175.

_____. 1950. Investigations on harvesting Deglet Noor dates including bunch cutting and delayed picking. Date Growers' Inst. Rpt. 27:22-25.

_____. 1952a. Association of sulfur content with acidity and quality in dates. Date Growers' Inst. Rpt. 29: 16-17.

_____. 1952b. The effect of sulfur dust and exposure to high temperatures on the sulfur content and acidity of immature Deglet Noor dates. Amer. Soc. Hort. Sci. Proc. 60:204-208.

_____. 1953. The relation of high temperatures to the prevalence of dry-textured fruit in the Deglet Noor date crop. U. S. Department of Agriculture., H.T.&S. Office Report No. 300, 5 pp. 11 figs. (Mimeographed).

_____. 1954a. Relation of dry texture in Deglet Noor dates to high spring temperature. Date Growers' Inst. Rpt. 31:4-5.

_____. 1954b. Quality of dates in some American markets. Date Growers' Inst. Rpt. 31: 20-26.

Rygg, G.L., J. R. Furr, R. W. Nixon and W. W. Armstrong. 1953. Factors affecting the spoilage of dates at room temperature. Date Growers' Inst. Rpt. 30: 10-14.

Shamblin, A.J. 1924. Eradication and control of date scale. Date Growers' Inst. Rpt. 1: 13-14.

Shamel, A.D.* 1930. A bud variation in the Deglet Noor date palm. Jour. Heredity 21(4): 164-166.

Sievers, A.F.* and W. R. Barger. 1930. Experiments on the processing and storing of Deglet Noor dates in California. U. S. Dept. Agr. Tech. Bul. 193, 24 pp., illus.

Stickney, F. 1924. Date palm insects. Date Growers' Inst. Rpt. 1: 16-17.

Stickney, F.S. 1934a. The external anatomy of the red date scale, Phoenicococcus Marlatti Cockrell and its allies. U. S. Dept. Agr. Tech. Bul 404 163 pp., illus.

_____. 1934b. The external anatomy of the Parlatoria date scale, Parlatoria Blanchardi Targioni Tozzetti, with studies of the head skeleton and associated parts. U. S. Dept. Agr. Tech. Bul. 421, 68 pp. illus.

_____, D. F. Barnes* and P. Simmons*. 1950. Date palm insects in the United States. U. S. Dept. Agr. Circ. 846, 57 pp., illus.

Swingle, W. T. 1901. The date palm and its culture. U. S. Dept. Agr. Yearbook 19 453-490, illus.

_____. 1904. The date palm and its utilization in the southwestern states U. S. Bur. Plant Indus. Bul. 53, 155 pp., illus.

_____. 1907. Starting a seedling date orchard. U. S. Bur. Plant Indus. Circ. 271, 4 pp.

_____. 1912. Maturation artificielle lente de la datte Deglet Noor. Comptes Rendus de l'Academie des Sciences (Paris) 155: 549-552.

_____. 1913. The present status of date culture in the southwestern state In U. S. Dept. of Agr. Bur. Plant Ind. Cir. 129: 3-7.

_____. 1924a. Cooperative quarantine date nurseries. Date Growers' Inst. Rept. 1: 25-26.

_____. 1924b. Low temperature dehydration of cane sugar dates. Date Growers' Inst. Rpt. 1:31-32.

_____. 1927. Date growing: a new industry for southwest states. U. S. Dept. of Agr. Yearbook 1926: 302-306.

_____. 1928. Metaxenia in the date palm. Jour. Heredity 19: 257-268.

_____. 1929. Date culture in southern Morocco. Date Growers' Inst. Rpt. 6: 16-19.

_____. 1931. New investigations on the correlation between root and leaf growth and the water requirements of the date palm. Date Growers' Inst. Rpt. 8: 7-9.

_____. 1945. Introduction of the Medjhool date from Africa into the United States. Date Growers' Inst. Rpt. 22: 15-16.

_____. 1947. The first successful introduction of standard varieties of date palms into the new world. Date Growers' Inst. Rpt. 24:21-22.

Thackery, F. A. 1931. Sterilization of soils withformalin. Date Growers' Inst. Rpt. 8:9-11.

_____. 1952. A few notes on the Medjool date during its isolation in Nevada. Date Growers' Inst. Rpt. 29: 8-10.

_____, and G. H. Leach. 1936. Progress report on preliminary cover crop trials. Date Growers' Inst. Rpt. 13: 17-18.

ADDENDA

Aldrich, W. W., C. L. Crawford, R. W. Nixon and Walter Reuther. 1942. Some factors affecting rate of date leaf elongation. Amer. Soc. Hort. Sci. Proc. 41: 77-84. (The rate of elongation of an unexpanded bud leaf can be easily and accurately measured for a period of about 3 weeks beginning when the tip of the leaf is about 12 inches above the fibre around the bud. It affords a useful index of water deficits in the date palm due to deficiency of soil moisture during the growing season. Rate of elongation is increased by leaf removal and decreased by a heavy crop of fruit or low leaf/bunch ratio.)

Magness, J. R.*, and H. P. Traub.* 1941. Dates. U. S. Dept. Agr. Yearbook 1941: 404-405. (Brief summary of conditions necessary for date culture.)

Mason, S. C. 1929. Date varieties at all growth stages shown by vegetative characters. U. S. Dept. Agr. Yearbook 1928: 256-257. (A list of leaf and palm characters by which date varieties may be identified).

_____. 1908. Date growing in southern California. Official Report of the 34th Fruit Growers' Convention of the State of California, pp. 170-178. (An outline of requirements for date culture. Predicted that "the American date gardens of the future will, more and more, contain American bred varieties.")

Nixon, R. W. 1932. Date ripening controlled beneficially by using special kinds of pollen. U. S. Dept. Agr. Yearbook 1932: 168-169. (The direct effect of pollen on the time of ripening of dates offers a means of partially adapting fruit maturity to climatic conditions.)

Swingle, W. T. 1928. Date plantings free from pests begun in irrigated Southwest. U. S. Dept. Agr. Yearbook 1927: 274-276. (Date offshoots after being subjected to a newly-developed heat treatment are free from all insects and have been used to start pest-free plantings in new localities.)

_____. 1934. New crops for the American Sahara. Scientific Monthly 39: 361-363. (A summary of the background and status of the date industry in the United States.)

Traub, H. P.*, and T. R. Robinson.* 1937. Improvement of subtropical fruits other than citrus. U. S. Dept. Agr. Yearbook Separate 1589: 26-35. (Brief history of early experimental importations of date offshoots; leading varieties listed with acreage planted; discussion of possibilities for date breeding and of date flowering and pollination as related to breeding.)